

WITH NEW TECHNOLOGY, WASTE-TO-ENERGY GOES GREEN

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ABSTRACT

Many cities are making long-range plans to find alternatives to municipal solid waste (MSW) disposal in landfills. Although a waste-to-energy (WTE) facility offers many advantages, concerns over negative environmental impacts and possible public opposition make this a very difficult choice.

This paper looks at the remarkable progress that has been made in Europe in reducing atmospheric emissions from WTE facilities. Emissions from the Muellverwertung Rugenberger Damm, or MVR facility in Hamburg, Germany are reviewed in detail and compared to the very strict emission requirements of the South Coast Air Quality Management District (SCAQMD) in southern California.

A United States Environmental Protection Agency (USEPA) emission-modeling program, run by ENVIRON International Corporation (ENVIRON) was used to predict ambient concentrations for criteria pollutants, such as NO_x and PM₁₀, and air toxics, such as dioxins and PCBs. These ambient concentrations were compared to SCAQMD criteria pollutant thresholds, along with cancer risk and hazard index thresholds. The results indicate that a modern, European WTE facility stands up well to SCAQMD emission requirements.

INTRODUCTION

In 1993, the City of Hamburg, Germany passed a resolution to completely stop relying on landfills for the disposal of municipal solid waste (MSW). In the same year, the European Council issued Directive 99/31/EC,

which required member states to develop a plan by July 16, 2001 to prevent or reduce, as far as possible, the negative affects on the environment caused by landfilling of waste. With the City of Hamburg taking the lead, Europe became serious about finding alternatives to landfilling of waste.

At the time they passed their resolution to eliminate the landfilling of waste, the City of Hamburg was already operating two, successful WTE facilities. A third facility was under construction, just a few months away from commissioning. Based on this experience, the City decided to construct a fourth WTE facility. Called Muellverwertung Rugenberger Damm, or MVR, the new facility would have a capacity of 320,000 metric tons per year. Of this amount, 200,000 metric tons would come from the City of Hamburg, and 120,000 metric tons would come from surrounding counties in the adjacent state of Lower Saxony.

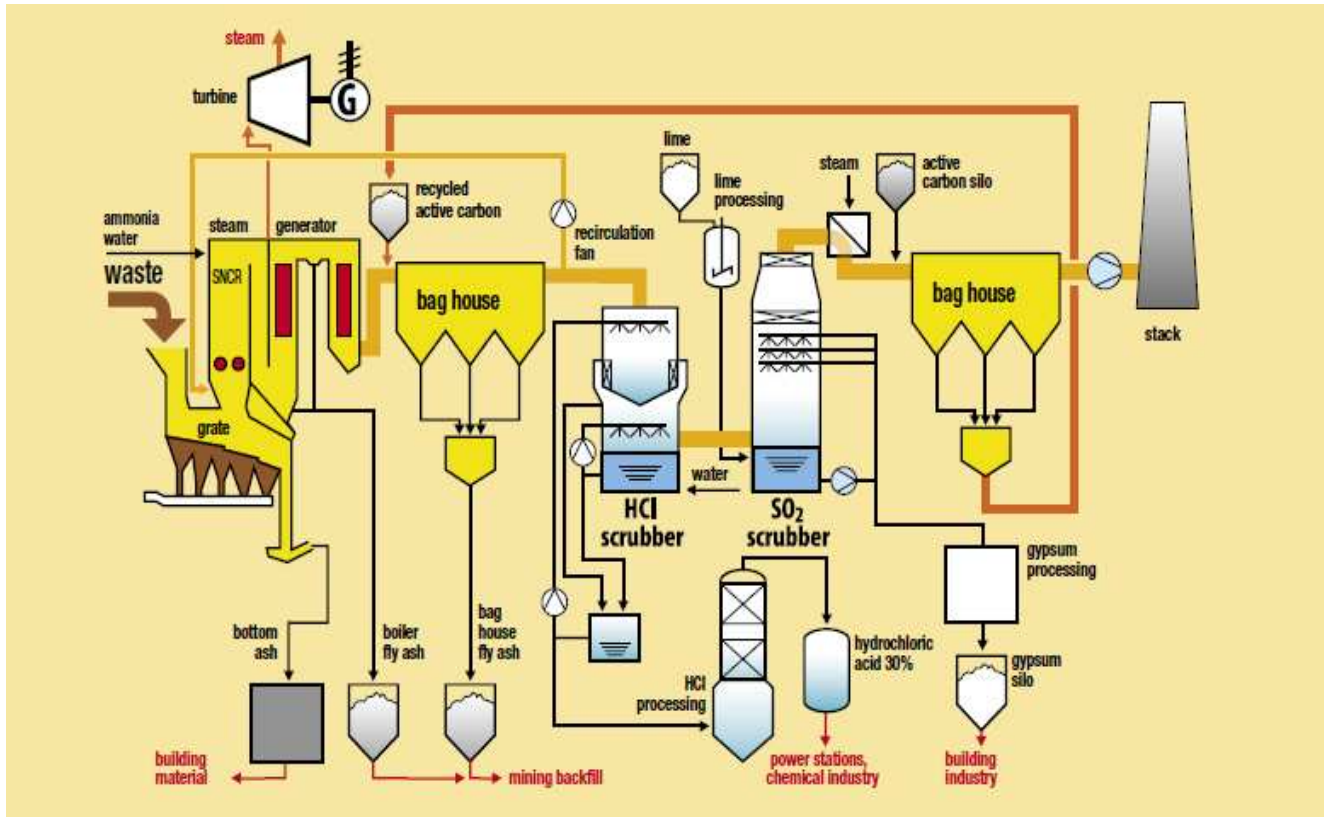
IMPORTANT NOTE ON WASTE-MANAGEMENT POLICY

It is important to note that the City of Hamburg, as is typical of most European cities, has a very ambitious recycling program. Approximately three-fourths of the MSW generated by the City is recycled. Only that waste which cannot be recycled is sent to one of the four WTE facilities used to treat City waste.

UNIQUE DESIGN IS NEEDED TO REPLACE A LANDFILL

Figure 1 provides a simplified flow diagram of the waste-treatment process at MVR.

FIGURE 1: SIMPLIFIED FLOW DIAGRAM OF MVR, HAMBURG, GERMANY



Note that the air pollution control system includes two bag houses and two scrubbers. The need for this seemingly additional equipment is not apparent until you realize that MVR has a dual purpose. First, the facility must meet very strict emission requirements while burning MSW to generate electrical power, steam for an industrial client and, beginning in 2004, hot water for district heating. Additionally, to meet the City of Hamburg's goal of eliminating waste disposal in landfills, the facility converts waste into products that meet the technical (DIN and EU) standards for these products, and thus have commercial value. As a result, treatment byproducts do not require disposal in a landfill; they can be sold in the appropriate markets. With this in mind, note the following points:

- Boiler fly ash and bag house fly ash, which contain heavy metals, dioxins and furans, are not mixed with the bottom ash. Instead they are removed from the process separately and used to stabilize caverns in salt mines. This is considered re-use in Germany according to the mining laws.
- The bottom ash is treated extensively to remove water-soluble minerals. This increases the value of the bottom ash as aggregate for construction projects.
- Particulates, metals, and halogenated compounds are removed from the flue gas in the first bag house by adding activated carbon. Hydrochloric acid (HCl) is

removed in the first scrubber before the flue gas is reacted with lime to produce gypsum. This raises the purity of the recovered gypsum to that of commercially sold gypsum.

- Hydrochloric acid recovered in the HCl scrubber is purified in a separate rectification unit to raise its quality to that of commercially sold hydrochloric acid.
- A combination of activated carbon and fabric filtration is used in the second bag house to remove essentially all of the remaining organic compounds and metals (mainly mercury) in the flue gas.

SUMMARY OF USABLE PRODUCTS PRODUCED FROM CITY WASTE

As noted, the process shown in the above flow diagram is used to convert City waste into a variety of usable products. Table 1 provides a summary of waste processed and materials recovered at MVR in 2005 (other years are comparable).

TABLE 1: WASTE CONVERSION AT MVR IN 2005

Item	Metric Tons
Waste Processed	339,782
Recovered Materials:	
Scrap metals sold to recyclers	7,929
Commercial hydrochloric acid	4,054
Commercial gypsum	947
Bottom ash sold as aggregate	75,000
Boiler fly ash*	3,577
Bag house filter fly ash*	4,278
Mixed salts*	2,070

*Used to stabilize caverns in salt mines

REVIEW OF ATMOSPHERIC EMISSIONS IN 2005

As noted, MVR is designed to produce electrical power and heat while meeting very strict limits on atmospheric emissions. Emissions from MVR in 2005 were compared

to current requirements in the South Coast Air Quality Management District (SCAQMD) in southern California. As reported to the Environmental Authority of the City of Hamburg, the annual emissions from MVR in 2005 are provided in Table 2.

TABLE 2: ANNUAL EMISSIONS FROM MVR FACILITY IN 2005

Pollutant	Annual Emissions
Criteria Pollutants:	
CO	21,624 kg
NO _x	87,595 kg
SO ₂	4,407 kg
PM (solid particulates only)	1,029 kg
C-total (related to VOC)	898 kg
Air Toxic Emissions:	
Hydrochloric acid	662 kg
Hydrofluoric acid	35 kg
Mercury	320 g
Cadmium and thallium	691 g
Metals (group of ten)	10.3 kg
Metals and BaP	2.2 kg
(four metals plus benzo-a-pyrene)	
Dioxins and furans (PCDD/F)	0.49 mg

INTRODUCTION TO THE 17TH ORDINANCE

WTE facilities operating in Germany are subject to the emission limitations specified in the "Seventeenth Ordinance on the Implementation of the Federal Immission Control Act," revised August 14, 2003. Commonly called the 17th Ordinance, this document represents the federal German emission limits, and they are the maximum, allowable emission limits for WTE facilities operating in Germany. Permitting authorities, such as the Authority for

Urban Development and the Environment of the City of Hamburg, are allowed to reduce these emission limits based on their assessment of local air quality, which includes measurements of the existing pollution. If the appropriate measurements are not available, the permit applicant must hire an independent and authorized laboratory to measure the air pollution for one year before applying for a permit. Additionally, the applicant must pay for all pollution measurements and reports. If the permitting authority decides the existing level of pollution

is critical, a permit will be granted only if the applicant can prove that additional pollution by the new facility will stay below one percent of the existing level of pollution. This must be proven by air-dispersion and emission modeling.

Several of the permit limits set by the City of Hamburg for MVR prior to construction are significantly below the limits in the 17th Ordinance. For example, the City of Hamburg limits for NO_x and dioxins/furans are one-half the limits in the 17th Ordinance, PM and HCl are 30 percent, the group of ten metals is 10 percent, and cadmium and thallium are only 4 percent of the limit of the 17th Ordinance. Despite the strict emission limits set by the City of Hamburg, the MVR facility operates well within all permit limits, as demonstrated by both continuous and periodic emission monitoring. Note that when emissions cannot be measured because they are below the detection limit of the measuring instruments, as is the case for metals, hydrofluoric acid and mercury, they are reported (estimated) to be 50 percent of the detection limit.

USING AIR-DISPERSION MODELING TO ASSESS SCAQMD COMPLIANCE

Complying with SCAQMD emission limitations is a real challenge, and rightfully so. Southern California has the worst ozone air quality in the United States (see <http://www.stateoftheair.org/2009/city-rankings/polluted-cities-ozone.html>). Not surprisingly, SCAQMD has some of the strictest emission limitations of any air district in the United States. To meet SCAQMD emission limitations, a significant new facility must use air-dispersion modeling to demonstrate compliance with limitations on criteria emissions and toxic air emission impacts,

The emission modeling for criteria emissions demonstrates that the new facility will not cause an unacceptable increase in the ambient concentration of criteria emissions in impacted areas surrounding the new facility. In comparison, emission modeling for toxic air emissions

evaluates the cancer, acute and chronic health risk posed by exposure to all of the air toxics released by the new facility. This is accomplished, in part, by using a United States Environmental Protection Agency (USEPA) model to predict the concentration air toxics released by the new source at the point of maximum impact by the new facility.

ESTIMATING SCAQMD CRITERIA POLLUTANTS FROM MVR

The five SCAQMD criteria pollutants are: carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate (both condensable and non-condensable) emissions with a diameter of ten microns or less (PM₁₀) and volatile organic compounds (VOCs). Emission reporting in Germany is similar to, but not quite the same as that used by SCAQMD. For this reason, some adjustments and assumptions are necessary.

At a typical U.S. WTE facility, 75 to 80 percent of the particulate emissions are solid or non-condensable, while the balance is condensable, aerosol-type particulates. Although the flue gas treatment process is not comparable and much less condensable matter can be expected in the MVR particle emission, the 1,029 kg PM emission reported above is divided by 0.75 to provide a conservative estimate of 1,372 kg total (condensable plus non-condensable) particulate emission loading. Again, being conservative, we should assume that all of the particulates are 10 microns or less in diameter. Making these two assumptions, the PM₁₀ emission, as defined by SCAQMD from MVR in 2005 was 1,372 kg.

VOC emissions can be estimated by dividing total carbon emissions by 1.3. Using this approximation, the 898 kg total carbon emission reported above should be divided by 1.3 to provide an estimated 691 kg VOC emission from MVR in 2005. Using the above estimates and conversions, Table 3 provides the estimated SCAQMD criteria emissions from MVR in 2005.

TABLE 3: ESTIMATED SCAQMD CRITERIA POLLUTANTS FROM MVR IN 2005

SCAQMD Criteria Pollutant	Annual Emissions
CO	21,624 kg
NO _x	87,595 kg
SO _x	4,407 kg
PM ₁₀	1,372 kg
VOC	691 kg

TOXIC AIR EMISSIONS FROM MVR

The method used to report toxic air emissions in Germany is not the same as that used by SCAQMD. In Germany,

toxic air emissions are reported both as single compounds and as groups, as required by the 17th Ordinance. This arrangement is summarized as follows:

Reporting Requirements for Toxic Emissions Under the 17th Ordinance

Single compounds:	Groups:
<ul style="list-style-type: none">• Hydrochloric acid• Hydrofluoric acid• Mercury	<ul style="list-style-type: none">• Cadmium and thallium• Heavy metals (V, Cr, Mn, Co, Ni, Cu, As, Sn, Sb, Pb)• Metals plus benzo-a-pyrene, a polyaromatic hydrocarbon (Cr, Co, As, Cd, BaP)

SCAQMD emission modeling requires data for each toxic air compound, requiring careful interpretation of the group data, such as the combined data for ten metals, reported to comply with the 17th Ordinance. From an engineering standpoint, the emission-control system must be designed to control dioxin and furan emissions, which are the most toxic of the toxic emissions, to the point where the health risk is acceptable. When this is accomplished, the emission-control system should capture much less toxic compounds (such as BaP and mercury) in the flue gas to the point where there will be no significant increase in the health risk.

BRIEF DESCRIPTION OF THE AIR DISPERSION MODEL

ENVIRON used SCREEN3 as the air-dispersion model for this analysis. SCREEN3 is a USEPA-approved screening air-dispersion model that is approved by SCAQMD for evaluation of air-toxics exposures. Screening dispersion models are applied before the refined air-dispersion model to determine if refined modeling is needed, and the results obtained from screening air models are more conservative as compared to the refined models. The SCREEN3 model provides maximum ground-level concentrations within an automated distance array, or at specified distances (i.e.,

TABLE 4: SOURCE PARAMETERS USED IN SCREEN3 MODELING OF MVR

Parameter	Value	Units
Stack flow	80,000	m ³ /hr
Stack Diameter	2.1	m
Stack exit temperature	125	°C
Stack Height	80	m
Stack Area	3.46	m ²
Stack exit velocity	6.42	m/s

receptors) within the array. Source parameters such as stack exit temperature, exit velocity, stack diameter, stack height, and emission rates are required to run SCREEN3. ENVIRON used the source parameters provided by MVR, as shown in Table 4 for SCREEN3 modeling of MVR emissions.

Note that MVR uses two, essentially identical incineration lines, called Line 1 and Line 2. Emissions are released from two, identical stacks, one for each line. For this reason, the velocity and temperature of the flue gas at the top of each stack is essentially the same. This flue velocity

and temperature, which determines the rise of the plume above the ground, is used in the emission model to predict the dispersion of the total emissions from both stacks, as discussed below.

The SCREEN3 model was run using a unit emission rate (i.e., 1.0 gram per second [g/sec]). Consequently, the predicted concentrations in the model output files are actually dispersion factors (i.e., χ/Q , $\mu\text{g}/\text{m}^3$ per g/sec), which can be used for any combination of the emission sources and/or pollutants.

RESULTS OF EMISSION MODELING

Criteria Pollutants and Toxic Air Contaminants

Table 5 presents the emission rates for both the criteria pollutants and the toxic air contaminants used in the analysis.

TABLE 5: EMISSION RATES USED FOR MODELING THE MVR FACILITY IN 2005

SCAQMD Criteria Pollutants	Kg/year	g/s¹
Particulate Matter (PM ₁₀)	1,372	4.71E-02
Carbon Monoxide	21,624	7.42E-01
Oxides of Nitrogen (NO _x)	87,595	3.01E+00
Sulphur Dioxide	4,407	1.51E-01
Air Toxics	Kg/year	g/s¹
Hydrochloric acid	662	2.27E-02
Hydrofluoric acid	35	1.20E-03
Cadmium and Thallium	0.69	2.37E-05
Mercury	0.32	1.10E-05
Metals (Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V+Sn)	10.30	3.53E-04
Other metals(As+BaP+Cd+Co+Cr)	2.20	7.55E-05
Dioxin/Furans (I-TEQ)	4.90E-07	1.68E-11

Notes:

1. The annual emissions are reported by MVR as the total of both incineration lines. A breakdown of emissions for each line is not available. Therefore, to calculate the emission rate in g/s, the annual reported emissions were divided by the average, total operating hours for both lines.

Calculation Factors	Description
8,052	Operating hours for Line 1 in 2005
8,137	Operating hours for Line 2 in 2005
8,094.5	Average operating hours per year for the two lines
1,000	g/kg
3,600	sec/hr

Modeled Concentrations for Criteria Pollutants

Table 6 presents the modeled concentrations for the criteria pollutants. The modeled concentrations were calculated by multiplying the emission rates with the dispersion factor obtained from SCREEN3 runs. It should

be noted that because the output from SCREEN3 runs is the maximum 1-hr concentration, time-averaging correction factors from USEPA were applied to calculate concentrations for various averaging periods.

TABLE 6: MODELED CONCENTRATIONS FOR CRITERIA POLLUTANTS

Criteria Pollutant	Averaging Period	Modeled Concentration ($\mu\text{g}/\text{m}^3$)
NO ₂	1-hour	12
	Annual	0.99
CO	1-hour	3.05
	8-hour	2.14
PM ₁₀	24-hour	0.0775
	Annual	0.0155
Sulfates	24-hour	0.249
Calculation Factor	Description	
4.114	($\mu\text{g}/\text{m}^3$)/(g/s); dispersion factor value obtained from SCREEN3 run	
Averaging Period	EPA Multiplying Factor for POINT Sources¹	
3 hours	0.9	
8 hours	0.7	
24 hours	0.4	
annual	0.08	

Notes:

1. "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised," EPA-454/R-92-019, page 4-15.

Maximum Ambient Criteria Pollutant Impacts

Table 7 presents the comparison of the modeled concentrations with the SCAQMD thresholds. It should be noted that the SCAQMD thresholds for NO₂ and CO are “combined” thresholds. For this reason, the background concentrations are added to the project impacts and then compared with the SCAQMD thresholds. Therefore, as a conservative estimate, the maximum background concentrations recorded at various AQMD monitoring stations in the Los Angeles County for the year 2007 were

chosen. The maximum value for 1-hr and 8-hr CO background concentration is for South Central LOS ANGELES County station for 2007 whereas the maximum 1-hr for NO₂ is for East San Gabriel Valley 1 and the annual average value is for Pomona/Walnut station for 2007. The thresholds from SCAQMD Rule 1303 Table A-2, which SCAQMD uses for new source review, were used for comparing the project impacts. As can be seen from Table 7, the impacts from the MVR facility are lower than the SCAQMD thresholds in Rule 1303 Table A-2.

TABLE 7: MAXIMUM AMBIENT CRITERIA POLLUTANT IMPACTS¹

Project + Background

Pollutant	Averaging Time	Modeled Impact from Project Emissions (µg/m ³)	Background Pollutant Concentration ³ (µg/m ³)	Maximum Project + Background Concentration (µg/m ³)	SCAQMD Threshold (µg/m ³)	Impacts > SCAQMD Threshold
NO ₂ ²	1-hour	12	225	238	500	No
	Annual	0.99	59.7	60.7	100	No
CO	1-hour	3.05	9,143	9,146	23,000	No
	8-hour	2.14	5,829	5,831	10,000	No

Incremental Analysis

Pollutant	Averaging Time	Modeled Impact from Project Emissions (µg/m ³)	SCAQMD Threshold (µg/m ³)	Impacts > SCAQMD Threshold
PM ₁₀	24-hour	0.08	2.5	No
	Annual	0.02	1	No
Sulfates ⁴	24-hour	0.25	1	No

Notes:

1. The SCAQMD thresholds for PM₁₀ and sulfates are incremental. The thresholds for NO₂ and CO are combined thresholds and, therefore, impacts from operation plus background pollutant concentrations are compared to the thresholds. The SCAQMD thresholds from Rule 1303 Table A-2 has been used for comparison purposes.

2. As a conservative estimate, it has been assumed that all NO_x is emitted as NO₂.

3. As a conservative estimate, the maximum background concentrations from various SCAQMD monitoring stations in Los Angeles County were chosen. Maximum value for 1-hr and 8-hr CO background concentration is for the South Central Los Angeles County station for 2007. The maximum 1-hr for NO₂ is for East San Gabriel Valley 1, and the annual average value is for Pomona/Walnut station for 2007.

4. Sulfates estimated by assuming 100% of SO_x emissions are sulfate, which is a very conservative estimate.

Cancer Risk and Health Hazard Calculations

As mentioned earlier and presented in Table 5, the MVR facility reports the emissions of toxic metals in a group,

and the emissions of individual toxic metals are not publicly available. ENVIRON reviewed the toxicities (cancer potency factor including multipathway factor for

cancer risks, chronic reference exposure level for chronic hazards and acute reference exposure level for acute hazards) for the various metals combined in the different groups and chose the metal having the highest toxicity as a surrogate to represent the particular emission group. As a conservative estimate, ENVIRON assumed that the total emissions from the group was in the form of the surrogate metal used to represent that particular group. For example,

arsenic has the highest cancer potency factor when combined with the multipathway factor and hence it was chosen as a surrogate to calculate the cancer risk associated with the group of heavy metals.

Table 8 presents the cancer risk calculations, Table 9 presents the chronic hazard index calculation and Table 10 presents the acute hazard index calculations.

TABLE 8: CANCER RISK CALCULATIONS FOR RESIDENTIAL RECEPTOR

Pollutant Name	Emission Rate (Q) (g/s)	Dispersion Factor (χ/Q)⁴ ($\mu\text{g}/\text{m}^3$)/(g/s)	Cancer Potency Factor (CP) (mg/kg-day)⁻¹	Multi Pathway Factor (MP)	Cancer Risk in a million
Cadmium and Thallium (Using cadmium as a surrogate)	2.37E-05	4.114	1.50E+01	1	0.03
Heavy Metals (Using arsenic as surrogate) ¹	3.53E-04	4.114	1.20E+01	4.78	1.93
Benzo-a-Pyrene ²	7.55E-05	4.114	3.90E+00	29.76	0.84
Dioxin/Furans (2,3,7,8 PCDD equivalent) ³	1.68E-11	4.114	1.30E+05	9.78	0.002
Total Cancer Risk (in a million)					2.8

Notes:

1. As shown in Table 5, the emissions of heavy metals for the MVR facility are reported in a group and data for individual metals are not publicly available. In the group for heavy metals, Arsenic has the highest value for cancer potency factor. Therefore as a very conservative estimate, the cancer-risk contribution from heavy metals was calculated assuming that all the heavy metal emissions reported from MVR facility were in the form of Arsenic.

2. Similar to Note 1 above, Benzo-a-Pyrene (BaP) has the highest cancer-potency factor amongst the group of compounds for which the emissions are reported as a combined number. Therefore, as a very conservative estimate, the cancer-risk contribution from the group containing BaP was calculated assuming that all the emissions reported in the group containing BaP were in the form of BaP.

3. The emissions for dioxin/furans were assumed to be reported as 2,3,7,8 PCDD toxicity-equivalent.

4. The dispersion factor is the max 1-hr value from SCREEN3 runs.

Calculation Factors

$$\text{Risk} = Q \times \chi/Q \times 0.08 \times \text{AF}_{\text{ann}} \times \text{MP} \times \text{DBR} \times \text{EVF} \times \text{CP} \times 10^{-6} \times 10^6$$

Where, the following parameters used the values from the tables in Attachment L of AQMD Risk Assessment Procedures for Rules 1401 and 212

Term	Explanation		
AFann	Annual concentration adjustment factor for residential receptor	Table 2C	1
DBR	Daily breathing rate for residential receptor (L/kg body weight-day)	Table 9A	302
EVF	Exposure value factor for residential receptor	Table 9B	0.96
CP	Cancer Potency Factor (mg/kg-day) ⁻¹	Table 8A	specific values
MP	Multipathway Factor for residential receptor	Table 8A	specific values
1.00E-06	Microgram to milligram conversion, liter to cubic meter conversion		
1.00E+06	Conversion to express the risk number over a million		
0.08	Conversion factor from one-hour χ/Q value to annual average χ/Q value.		

TABLE 9: CHRONIC HAZARD INDEX CALCULATIONS

Pollutant Name	Emission Rate (Q) (g/s)	Dispersion Factor (χ/Q) ($\mu\text{g}/\text{m}^3$)/(g/s)	Chronic Reference Exposure Level (REL) ($\mu\text{g}/\text{m}^3$)	Multi Pathway Factor (MP)	Chronic Hazard Index³
Heavy Metals (Using Arsenic as a surrogate) ¹	3.53E-04	4.114	3.00E-02	1.91	7.4E-03
Mercury	1.10E-05	4.114	9.00E-02	10.06	4.0E-04
Hydrochloric acid	2.27E-02	4.114	9.00E+00	1	8.3E-04
Dioxin/Furans (2,3,7,8 PCDD equivalent) ²	1.68E-11	4.114	4.00E-05	11.5	1.6E-06
Total Chronic Hazard Index					8.6E-03

Notes:

1. As shown in Table 5, the emissions of heavy metals for the MVR facility are reported in a group, and data for individual metals are not publicly available. In the group for heavy metals, Arsenic has the lowest value for reference exposure level and, hence, has the highest chronic toxicity. Therefore, as a very conservative estimate, the chronic hazard index contribution from heavy metals was calculated assuming that all the heavy metal emissions reported from MVR facility were in the form of Arsenic.

2. The emissions for dioxin/furans were assumed to be reported as 2,3,7,8 PCDD toxicity equivalent.

3. As per SCAQMD guidelines, the chronic hazard index is calculated specific to the target organs that are affected by a particular toxic air contaminant. However, to have a conservative estimate, the total chronic hazard index has been calculated by adding up the chronic hazard index contribution for all the compounds, irrespective of the target organ the particular toxic air contaminant affects.

Calculation Factors

Chronic hazard Index = $Q \times \chi/Q \times 0.08 \times \text{MP}/\text{REL}$

Where, the following parameters used the values from the tables in Attachment L of AQMD Risk Assessment Procedures for Rules 1401 and 212

Term	Explanation		
REL	Reference Exposure Level ($\mu\text{g}/\text{m}^3$)	Table 8A	specific values
MP	Multipathway Factor	Table 8A	specific values
0.08	Conversion factor from one-hour χ/Q value to annual average χ/Q value.		

TABLE 10: ACUTE HAZARD INDEX CALCULATIONS

Pollutant Name	Emission Rate (Q) (g/s)	Dispersion Factor (χ/Q) ($\mu\text{g}/\text{m}^3$)/(g/s)	Acute Reference Exposure Level (REL) ($\mu\text{g}/\text{m}^3$)	Acute Hazard Index²
Heavy Metals (Using Arsenic as a surrogate) ¹	3.53E-04	4.114	1.90E-01	7.7E-03
Mercury	1.10E-05	4.114	1.80E+00	2.5E-05
Hydrochloric acid	2.27E-02	4.114	2.10E+03	4.5E-05
Total Acute Hazard Index				7.7E-03

Notes:

1. As shown in Table 5, the emissions of heavy metals for the MVR facility are reported in a group and data for individual metals are not publicly available. In the group for heavy metals, Arsenic has the lowest value for acute reference exposure level and, hence, has the highest acute toxicity. Therefore, as a very conservative estimate, the acute hazard index contribution from heavy metals was calculated assuming that all the heavy metal emissions reported from MVR facility were in the form of Arsenic.

2. As per SCAQMD guidelines, the acute hazard index is calculated specific to the target organs that are affected by a particular toxic air contaminant. However, to have a conservative estimate, the total acute hazard index has been calculated by adding up the acute hazard index contribution for all the compounds, irrespective of the target organ the particular toxic air contaminant affects.

Calculation Factors

Acute hazard Index = $Q \times \chi/Q / \text{REL}$

Term	Explanation		
REL	Reference Exposure Level ($\mu\text{g}/\text{m}^3$)	Table 8A	specific values

SCAQMD Rule 1401, SCAQMD New Source Review for Toxics, has a threshold of cancer risk of 10 in a million for equipment meeting toxics-Best Available Control Technology (T-BACT) requirements. As mentioned earlier, the MVR facility has two bag houses combined with activated carbon and two scrubbers installed as the air pollution control system. The air pollution control system at MVR therefore meets the T-BACT requirement as the baghouses in combination with activated carbon remove the organic and metal toxics. The chronic and acute hazard index threshold in Rule 1401 is 1. As seen from Tables 9 and 10, the MVR facility also complies with this threshold. Therefore the MVR facility meets the New Source Review requirements of SCAQMD for toxics.

Concluding Comments

ENVIRON used SCREEN3, a USEPA and SCAQMD-approved screening air-dispersion model, to determine

whether emissions from MVR, a modern, European WTE facility in Hamburg, Germany meet SCAQMD New Source Review requirements for both criteria pollutants and toxics. Based on the modeling results, the MVR emissions do indeed meet SCAQMD New Source Review requirements. This is significant for two reasons. First, SCAQMD emission requirements are among the most restrictive in the United States. Secondly, the MVR facility converts 98 percent of the treated waste into usable, commercial products, which can be sold, thus offering a true replacement for landfills.

Today, as city planners and waste professionals consider their options to disposal of MSW in a landfill, they now know that wherever they may be located, construction of an MVR-type facility should allow them to meet local emission requirements and greatly reduce their reliance on landfills for future waste disposal.

REFERENCES

2006 Environmental Statement, Muellverwertung Rugenberger Damm (MVR), Hamburg, Germany

“Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised,” EPA-454/R-92-019

South Coast Air Quality Management District, 21865 E. Copley Drive, Diamond Bar, CA 91765, Regulation XIII – New Source Review, Regulation XIV – Toxics and Rule 212 – Standards for Approving Permits and Issuing Public Notice